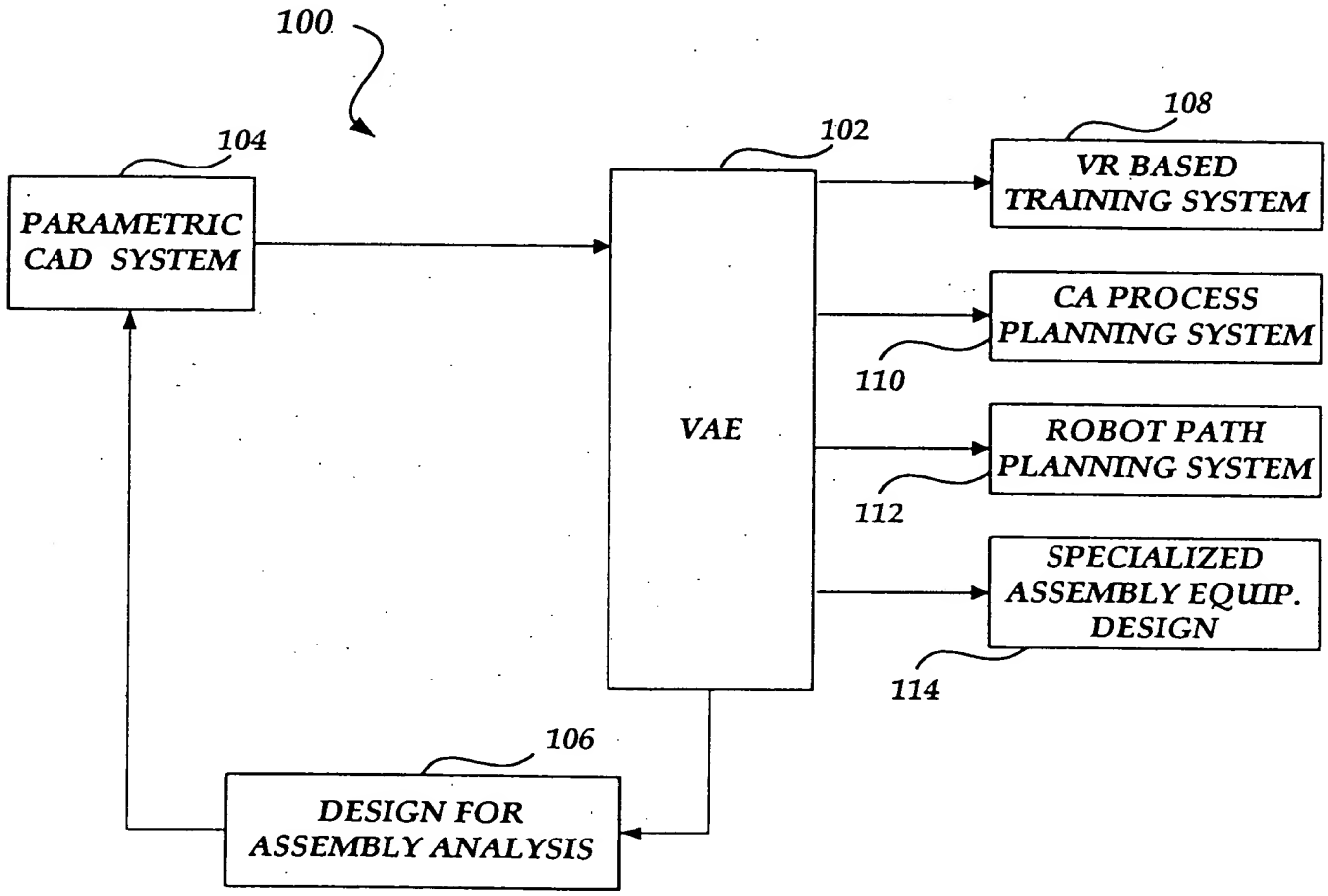
100
104
PARAMETRIC CAD SYSTEM
102
VAE
108
VR BASED TRAINING SYSTEM
CA PROCESS PLANNING SYSTEM
110
ROBOT PATH PLANNING SYSTEM
112
SPECIALIZED ASSEMBLY EQUIP. DESIGN
114
106
DESIGN FOR ASSEMBLY ANALYSIS

FIG. 1

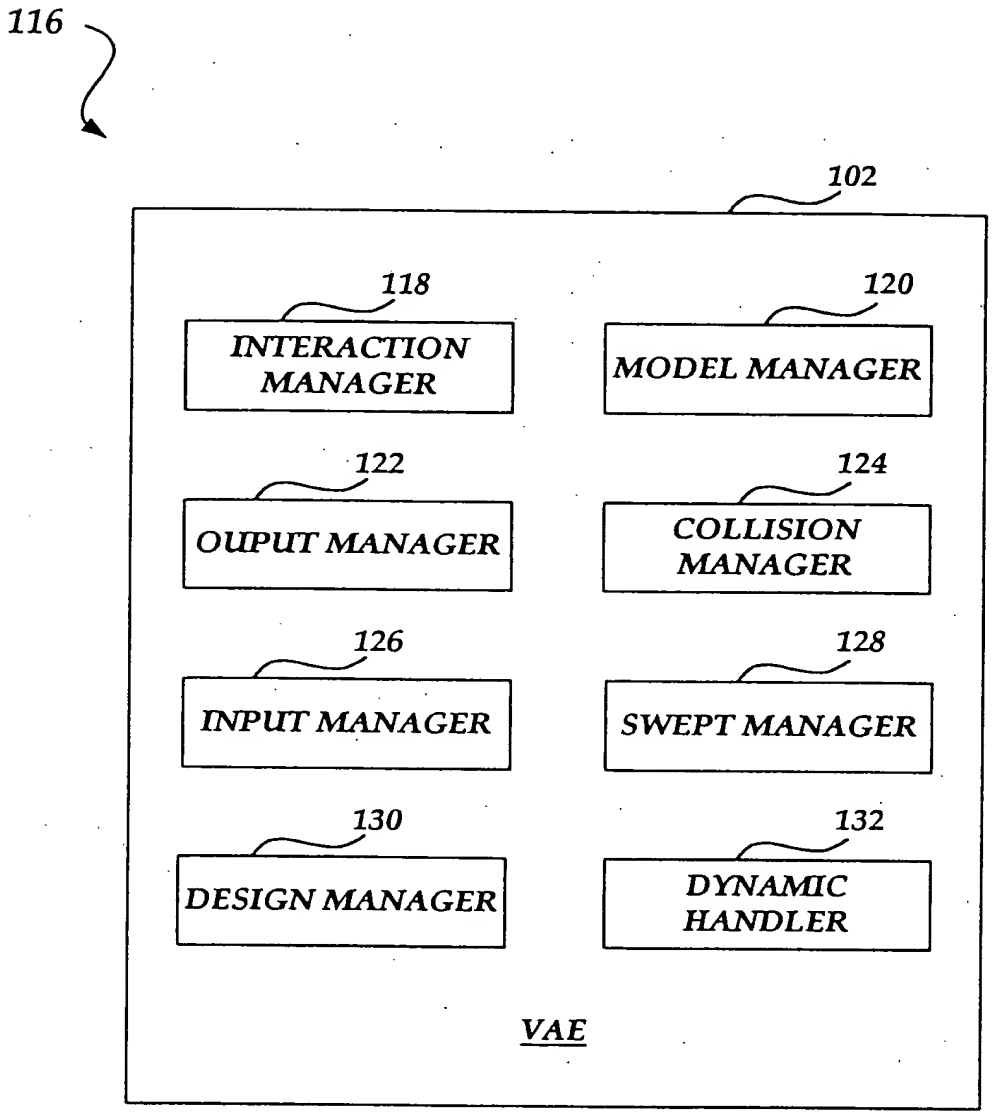
116
102
118
INTERACTION MANAGER
120
MODEL MANAGER
122
OUPUT MANAGER
124
COLLISION MANAGER
126
INPUT MANAGER
128
SWEPT MANAGER
130
DESIGN MANAGER
132
DYNAMIC HANDLER
VAE

FIG. 2

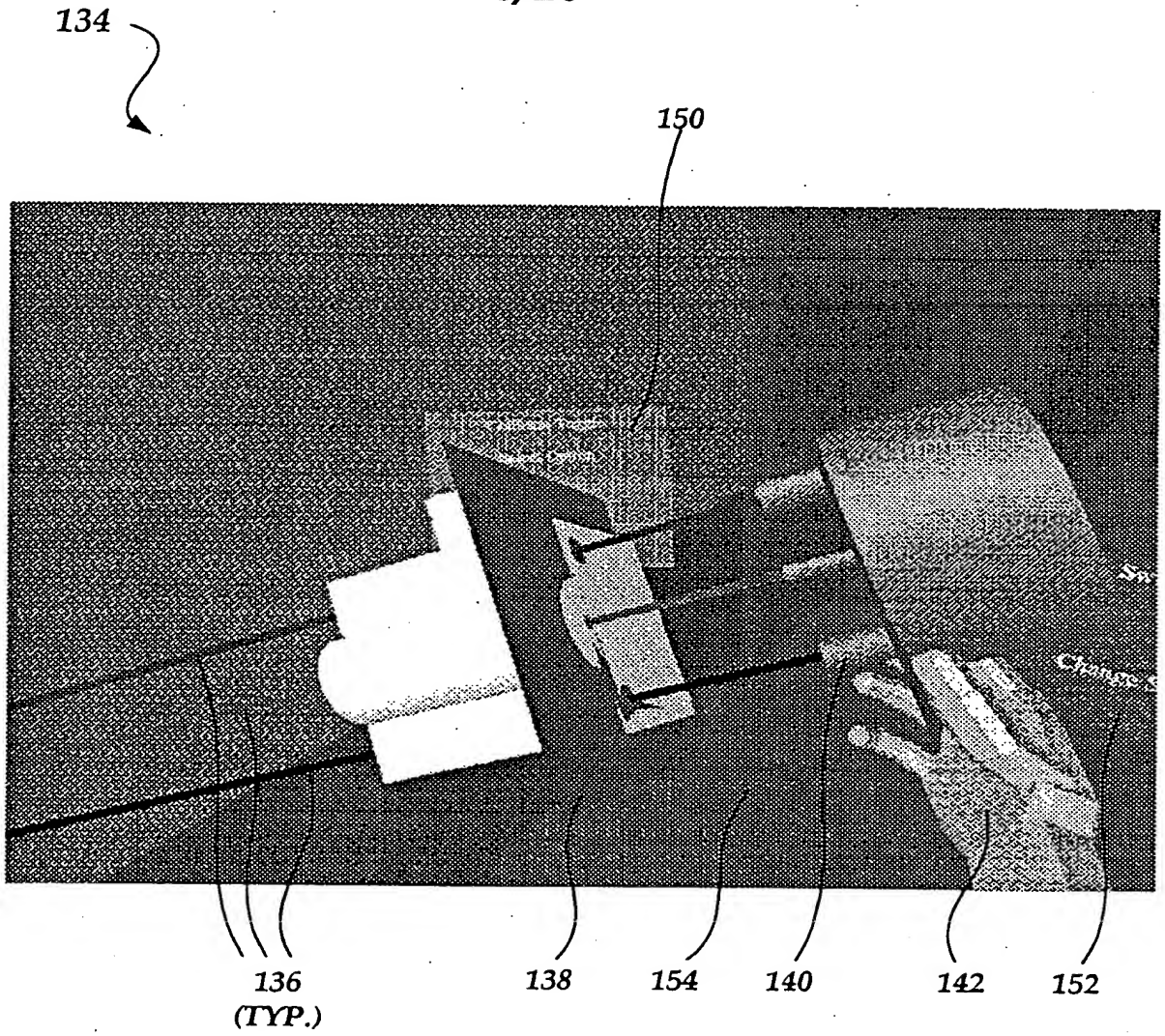

FIG. 3

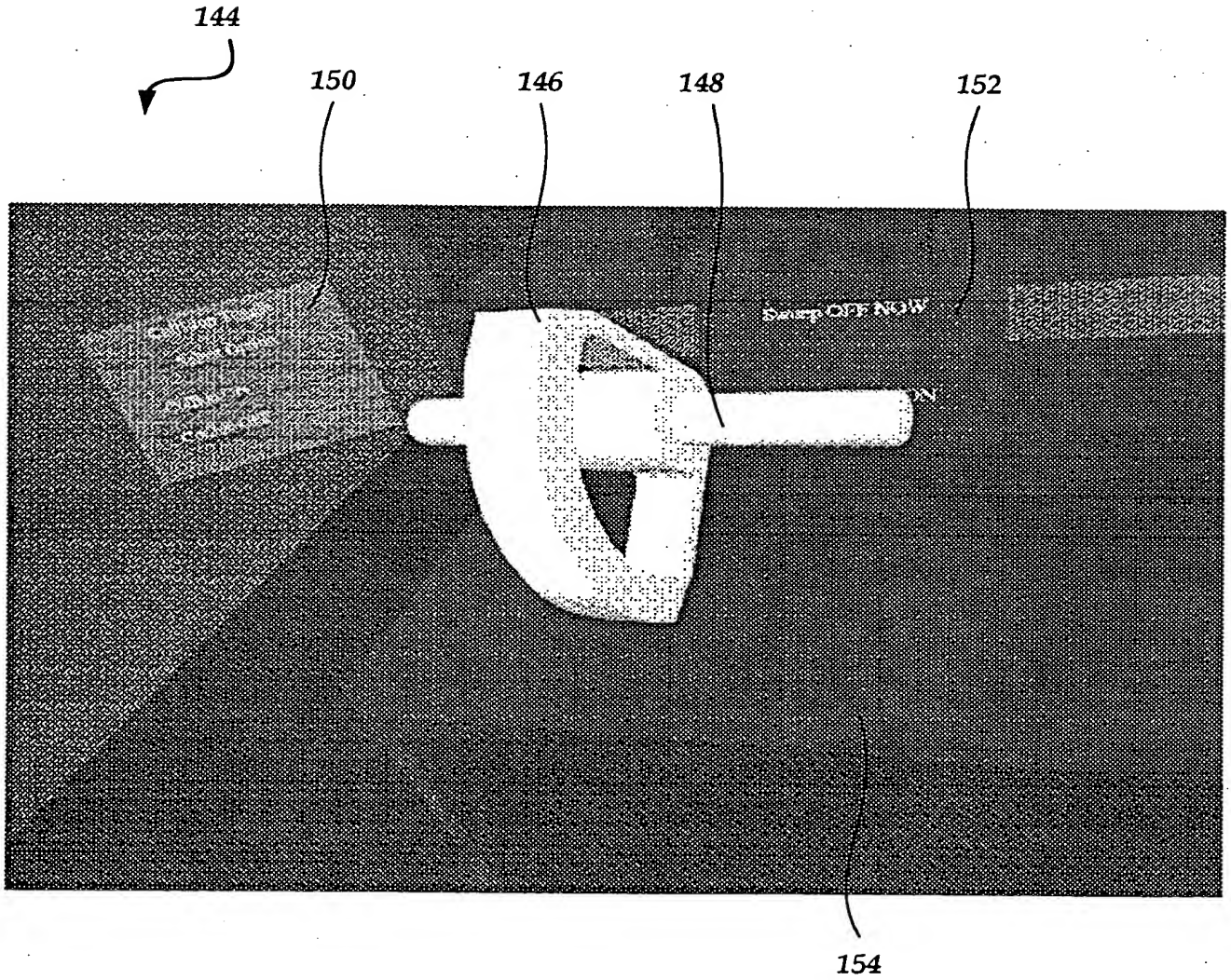

FIG. 4

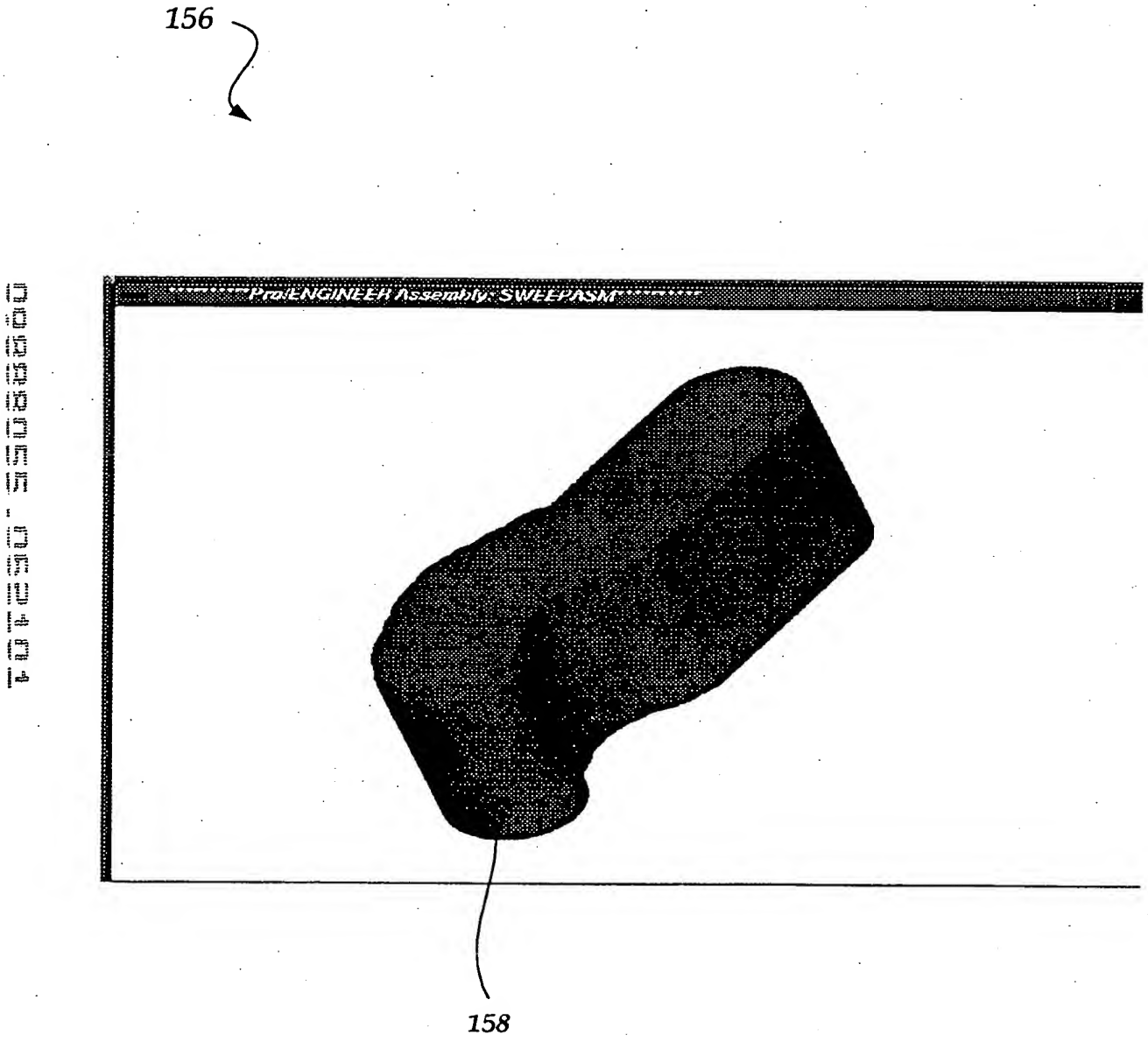

FIG. 5

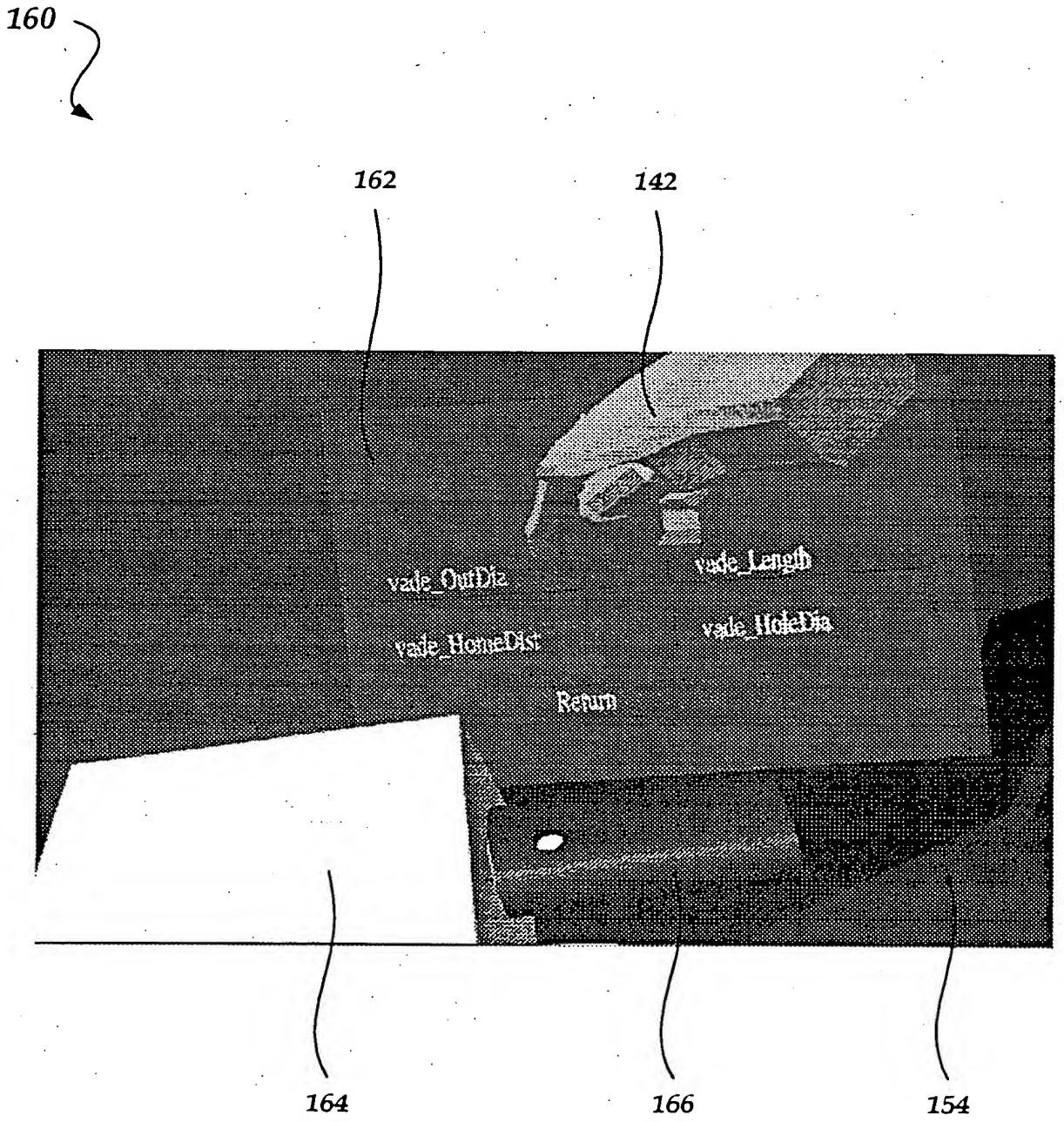
160
162
142
vade_OutDia
vade_Length
vade_HomeDist
vade_HoleDia
Return
164
166
154

FIG. 6

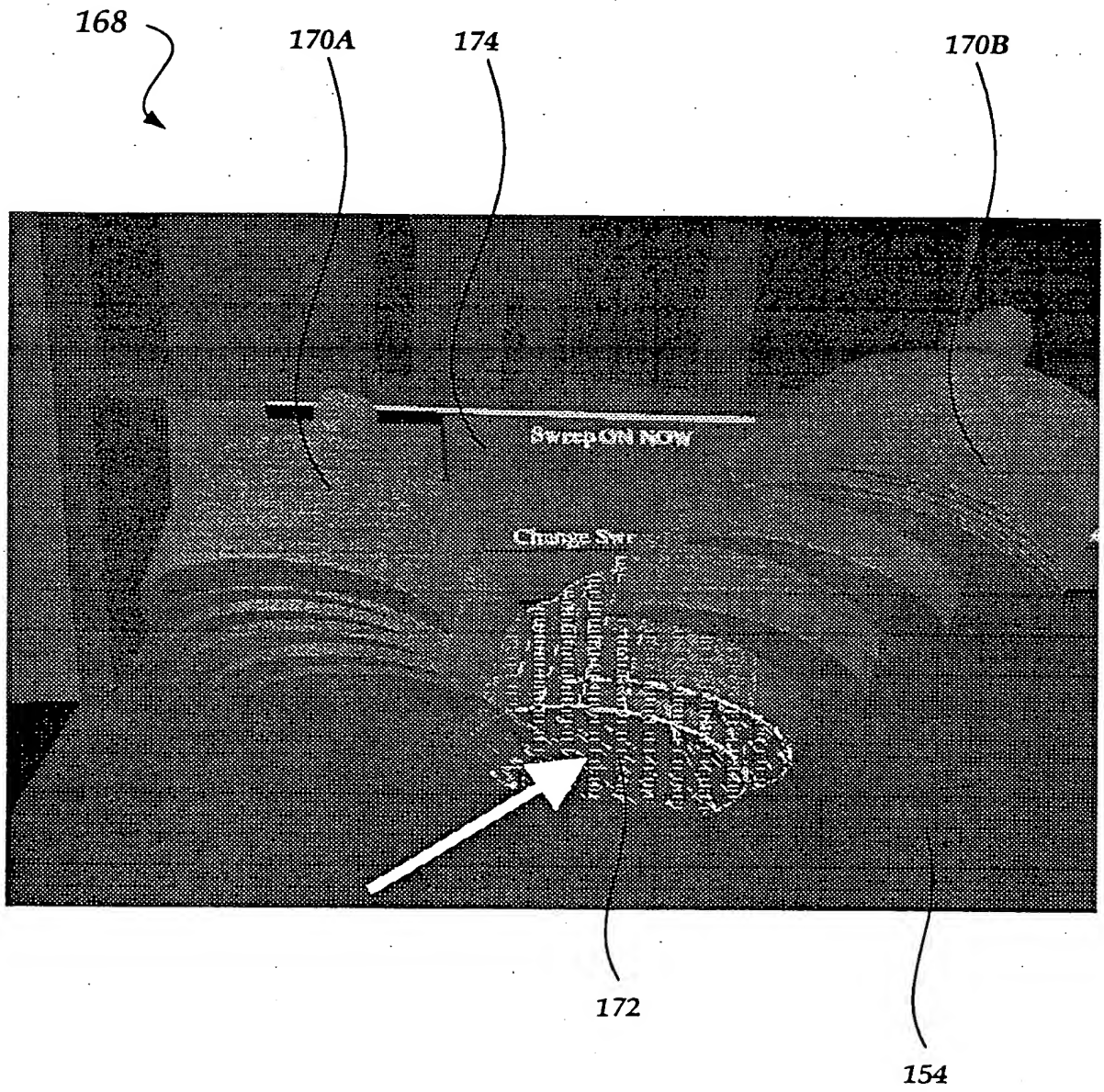

FIG. 7

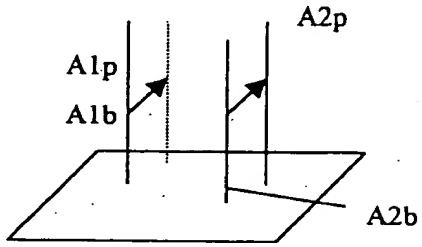

FIG. 8

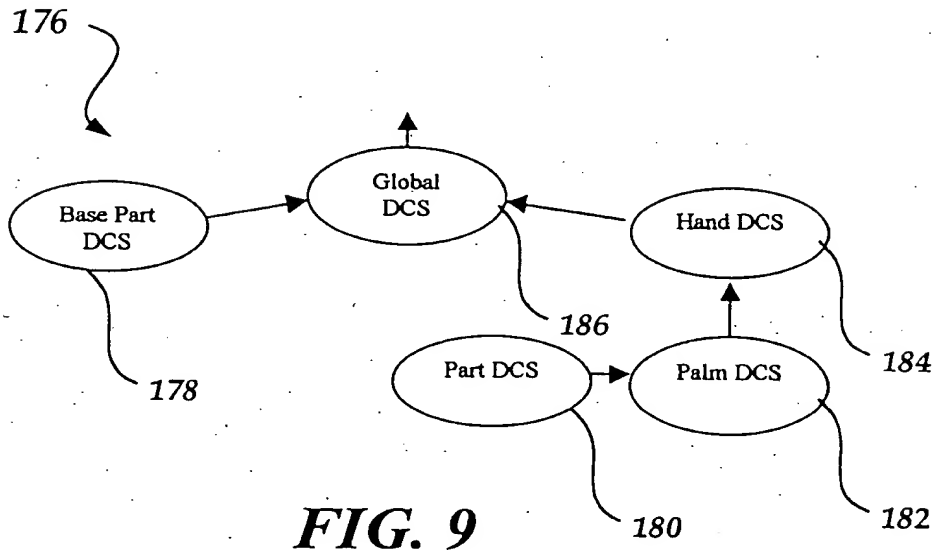

FIG. 9

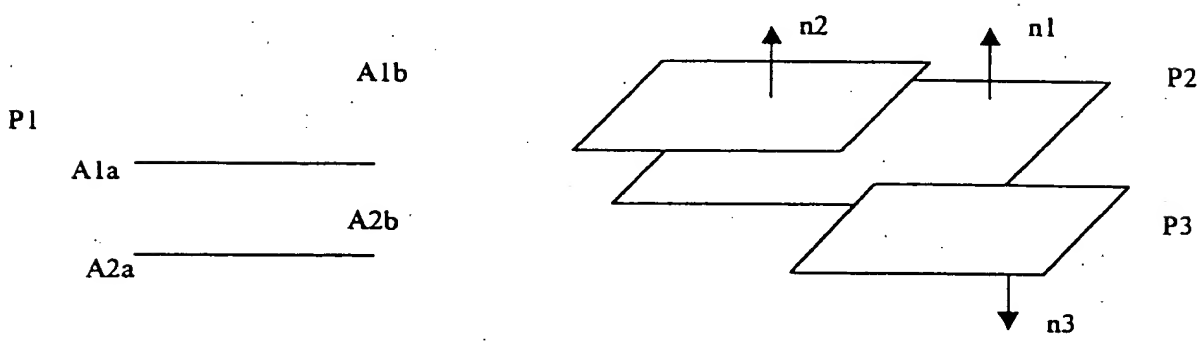

FIG. 10

FIG. 11

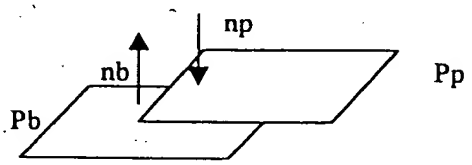

FIG. 12

Combination and order	Conditions
A1, A2	A1 n// A2
A1, A2, A3	A1 // A2, A1 n// A3
A1, A2, P3	A1 // A2, A1 n// P3
A1, P2	A1 n// P2, A1 n⊥ P2
A1, P2, A3	A1 // P2, A1 n// A3
A1, P2, P3	A1 // P2, A1 n// P3
A1, P2, A3	A1 ⊥ P2, A3 any case
A1, P2, P3	A1 ⊥ P2, P2 n// P3
P1, A2	P1 n// A2, P1 n⊥ A2
P1, A2, A3	P1 // A2, A2 n// A3
P1, A2, P3	P1 // A2, A2 n// P3
P1, A2, A3	P1 ⊥ A2, A3 any case
P1, A2, P3	P1 ⊥ A1, P1 n// P3
P1, P2, A3	P1 n// P2, (intersection line of P1, P2) n// A3
P1, P2, P3	P1 n// P2, P1 n// P3, P2 n// P3

FIG. 13

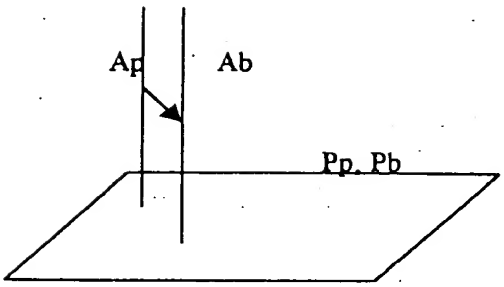

FIG. 14

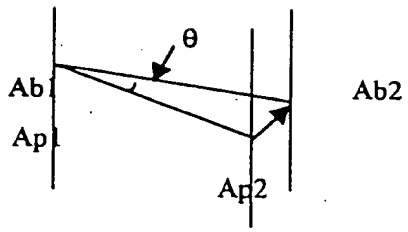

FIG. 15

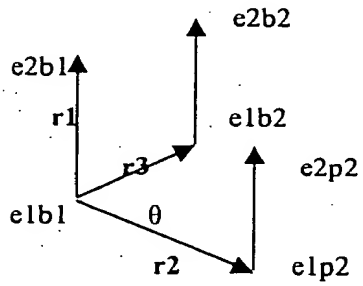

FIG. 16

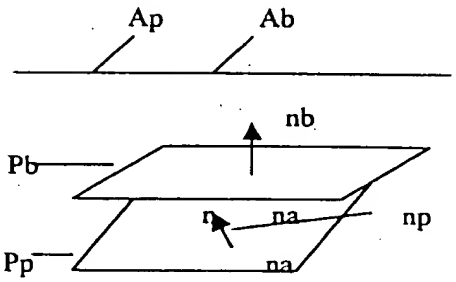

FIG. 17

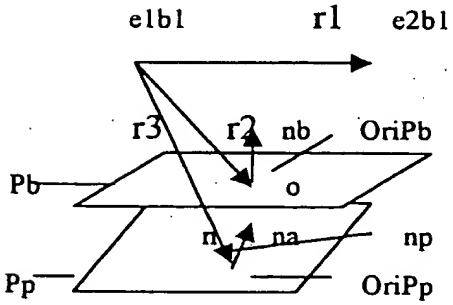

FIG. 18

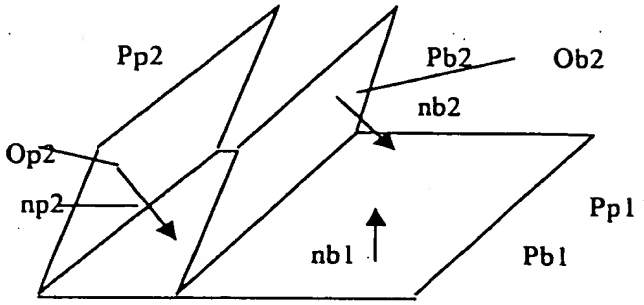

FIG. 19

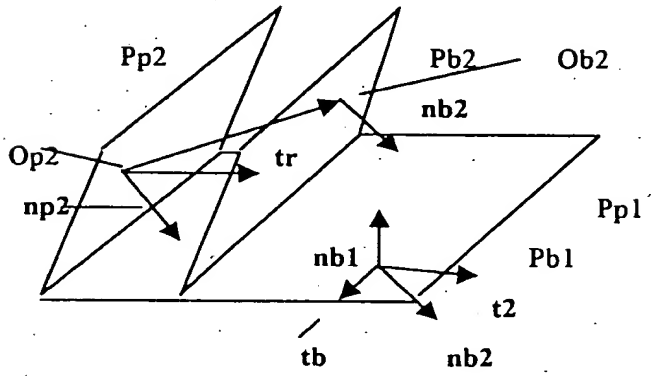
Pp2
Pb2
Ob2
nb2
Op2
tr
np2
Pp1
nb1
Pb1
t2
tb
nb2

FIG. 20

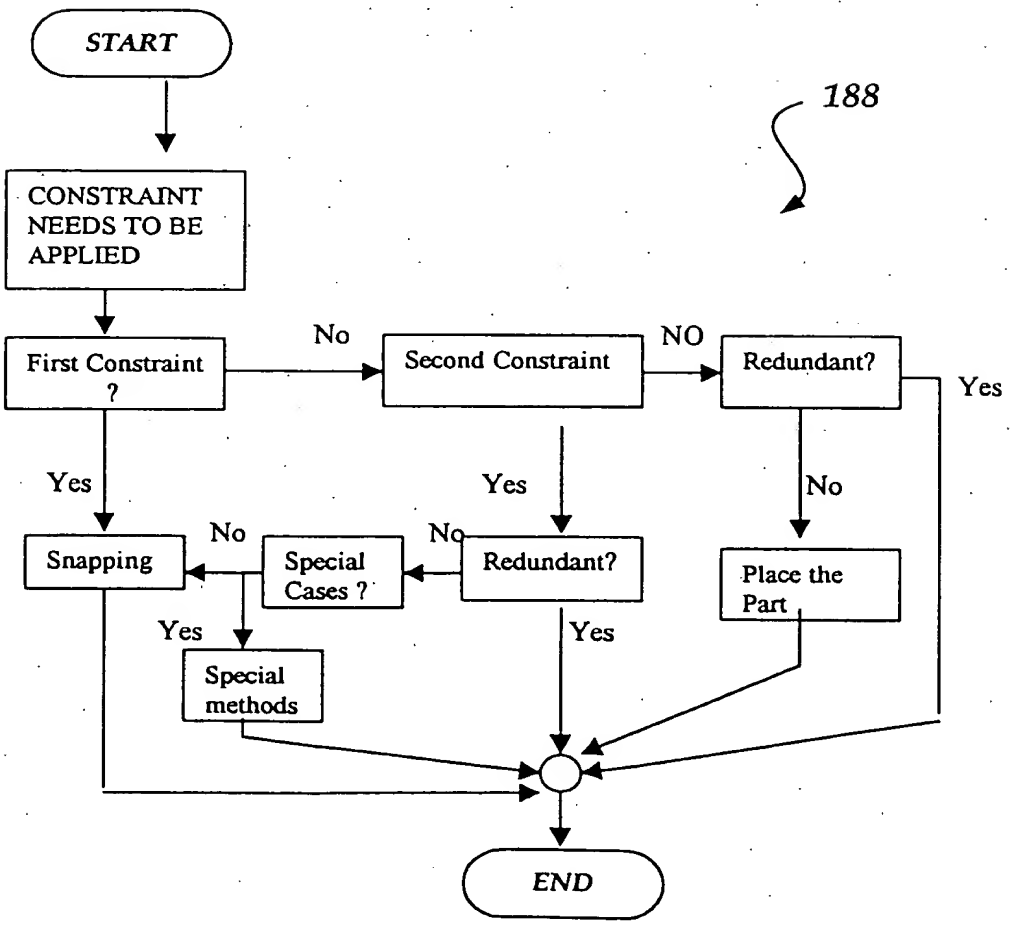
START
188
CONSTRAINT NEEDS TO BE APPLIED
First Constraint ?
No
Second Constraint
NO
Redundant?
Yes
Yes
Yes
No
Snapping
No
Special Cases ?
No
Redundant?
Place the Part
Yes
Yes
Special methods
END

FIG. 21

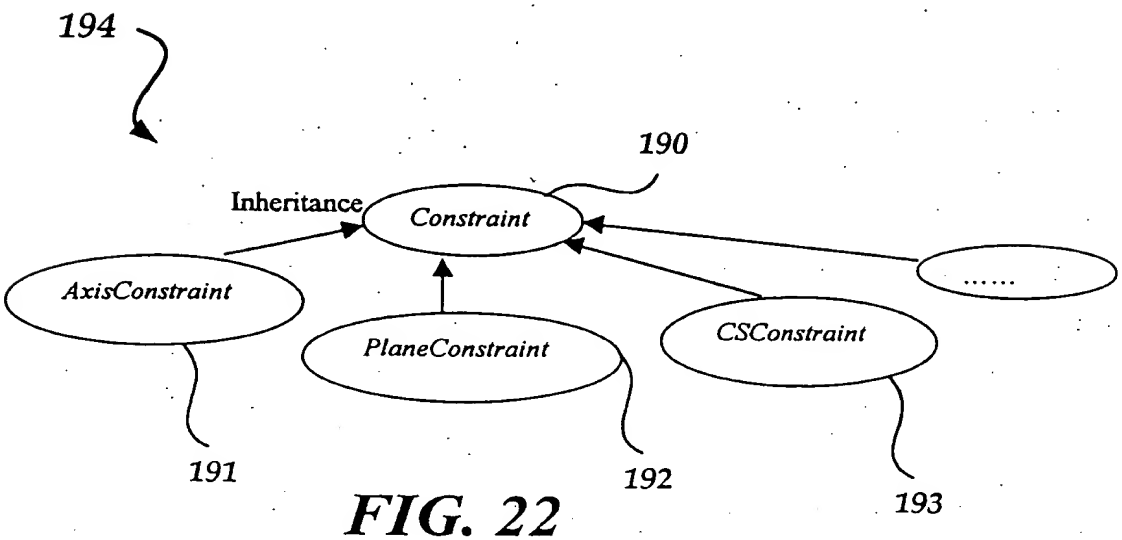

FIG. 22

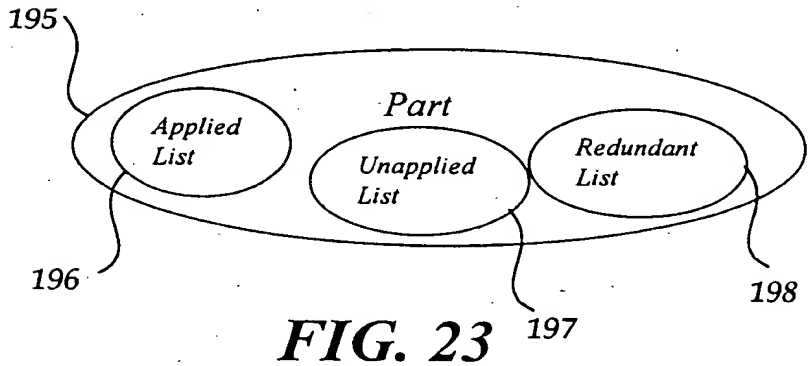

FIG. 23

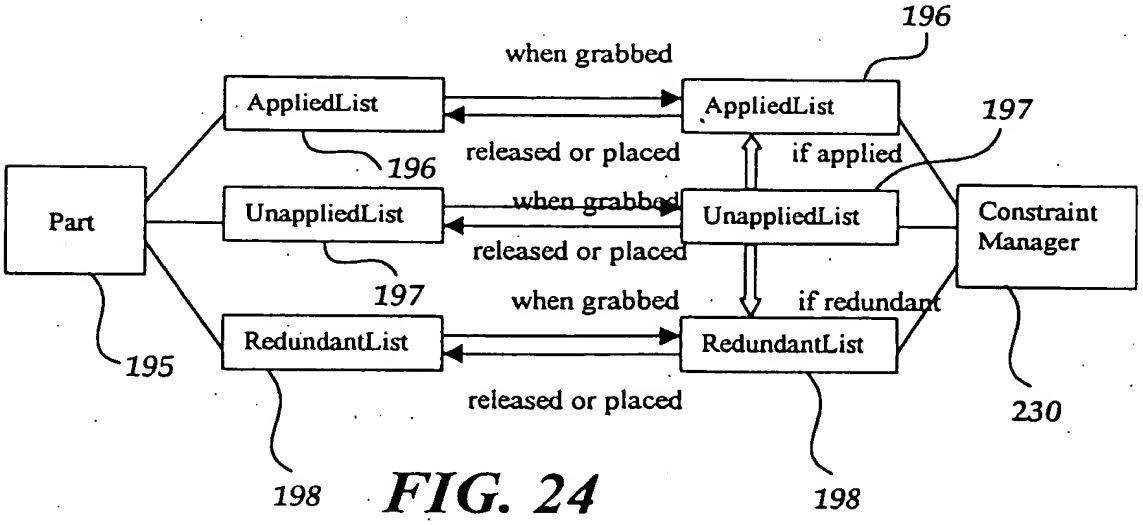

FIG. 24

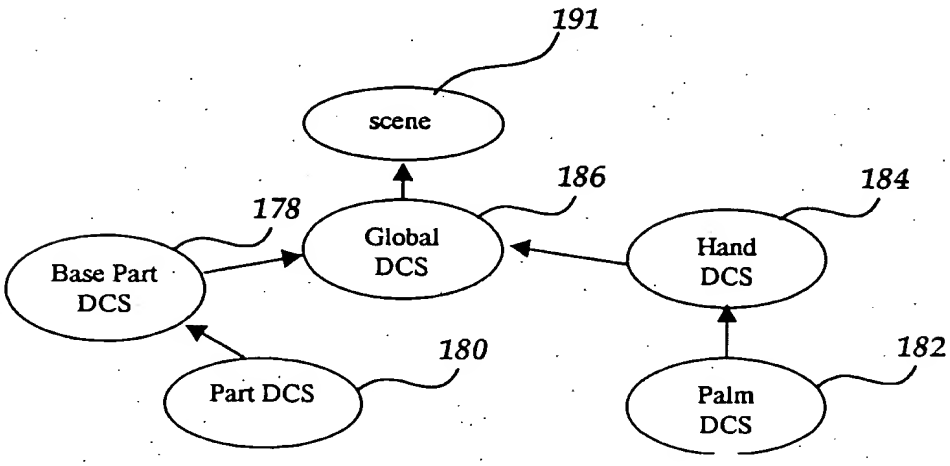
191
scene
186
184
178
Global DCS
Base Part DCS
Hand DCS
180
182
Part DCS
Palm DCS

Fig. 25

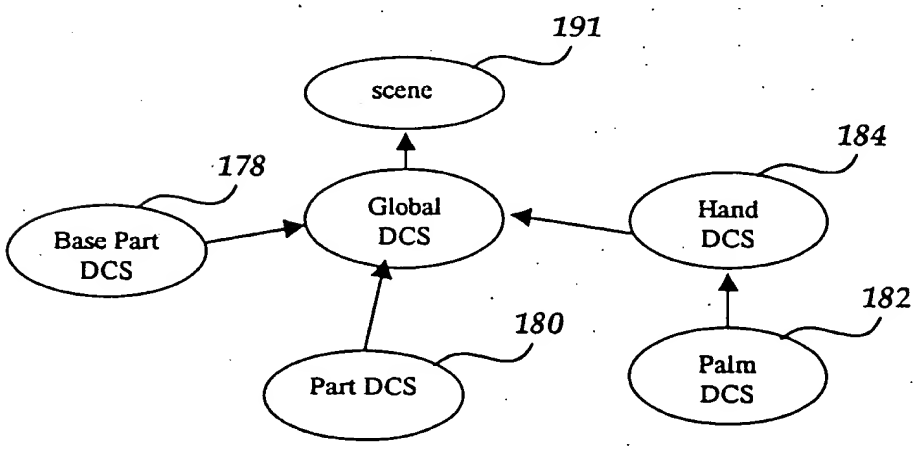
191
scene
184
178
Global DCS
Base Part DCS
Hand DCS
182
180
Part DCS
Palm DCS

Fig. 26

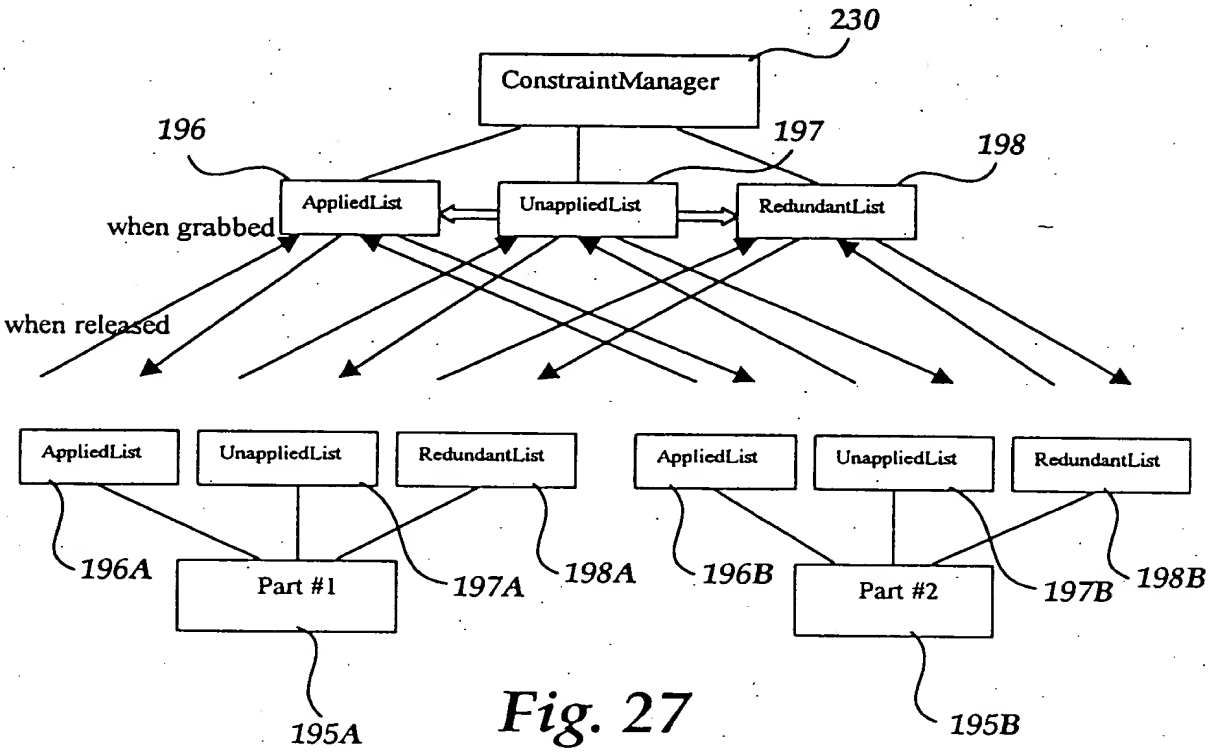
230
ConstraintManager
196
197
198
AppliedList
UnappliedList
RedundantList
when grabbed
when released
AppliedList
UnappliedList
RedundantList
196A
197A
198A
Part #1
195A
AppliedList
UnappliedList
RedundantList
196B
197B
198B
Part #2
195B

Fig. 27

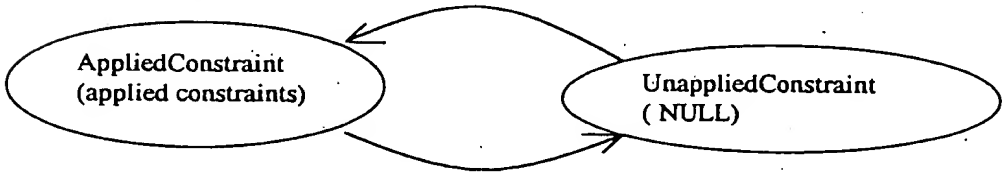
AppliedConstraint
(applied constraints)
UnappliedConstraint
(NULL)

Fig. 28

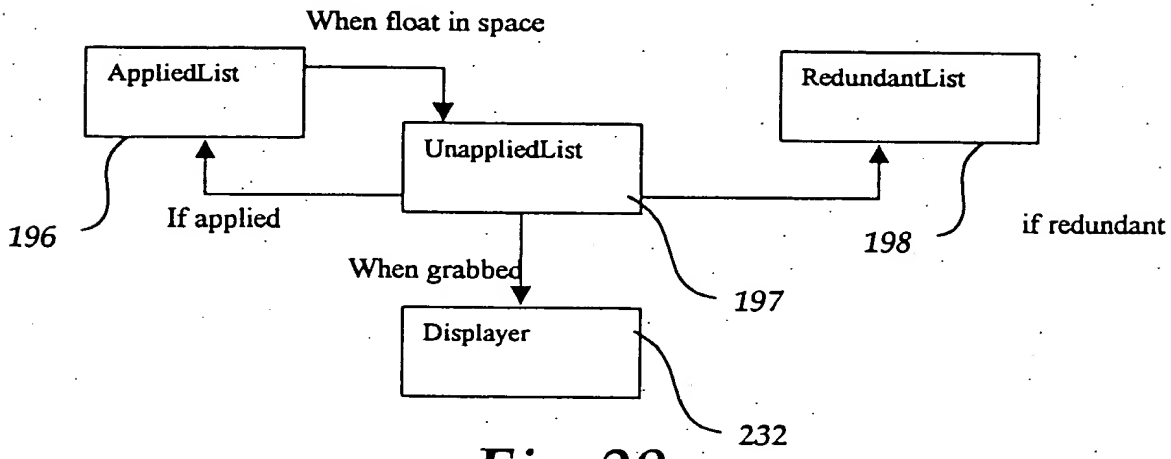

Fig. 29

```
crank property file

LENGTH UNITS: Inch
MASS UNITS: Pound
Surface Finish: 0.001000
Default Linear Tolerances: +- 0.100000  +- 0.010000  +- 0.001000
Default Angular Tolerances:      ANG+- 0.500000
Volume:     12.6798973
Surface Area:     69.5717665
Density:      1.0000000
Mass:     12.6798973

CENTER OF GRAVITY wrt DefaultCSC0 coordinate frame: X Y Z
                      0.0000000      1.1668295      0.5907307

INERTIA wrt DefaultCSC0 coordinate frame:
INERTIA TENSOR:
Ixx Ixy Ixz          69.0504703     -0.0536521      0.0000182
Iyx Iyy Izz          -0.0536521     17.8369050     -3.1957782
Izx Izy Izz           0.0000182     -3.1957782     68.8163268

INERTIA at CENTER OF GRAVITY wpt (Axis aligned) DefaultCSC0 coordinate
frame:
INERTIA TENSOR:
Ixx Ixy Ixz          47.3620913     -0.0536521      0.0000182
Iyx Iyy Izz          -0.0536521     13.4120927      5.5442472
Izx Izy Izz           0.0000182      5.5442472     51.5527601

PRINCIPAL MOMENTS OF INERTIA(wrt MC):
I1  I2  I3           12.6224281     47.3621611     52.3423549

ROTATION MATRIX from DefaultCSC0 orientation to PRINCIPAL AXES:
                      0.0015290     -0.9999977     -0.0015153
                      0.9900096      0.0013001      0.1409941
                     -0.1409918     -0.0017157      0.9900093
```

Fig. 30

Lifting Capacity for infrequent movement and short distances (pounds)

		Men	Women
1.	Both hands in front Or one hand at side	60	40
2.	Both hands 20 inches in front	20	13.3
3.	Each hand at side	30	20
3.	One hand or each 5 inch out	35	23.3

Fig. 31

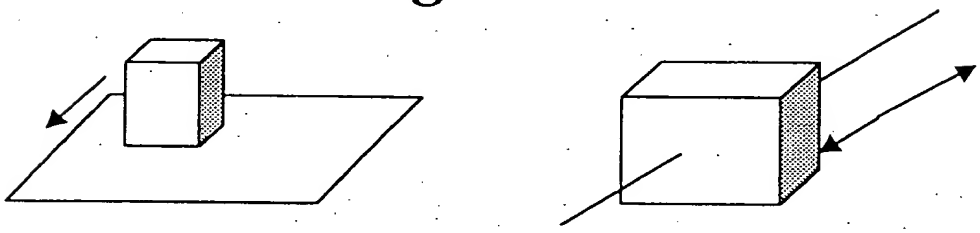

Fig. 32

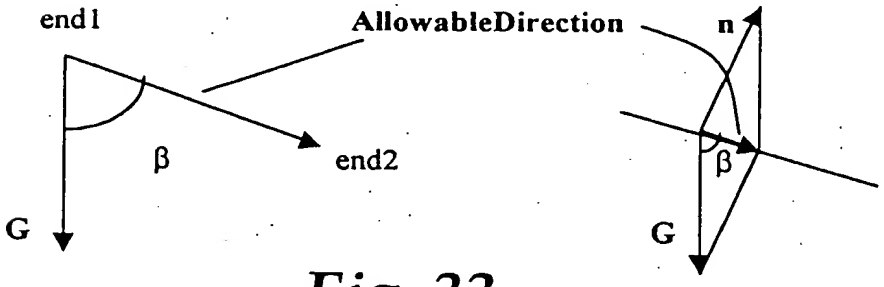

Fig. 33

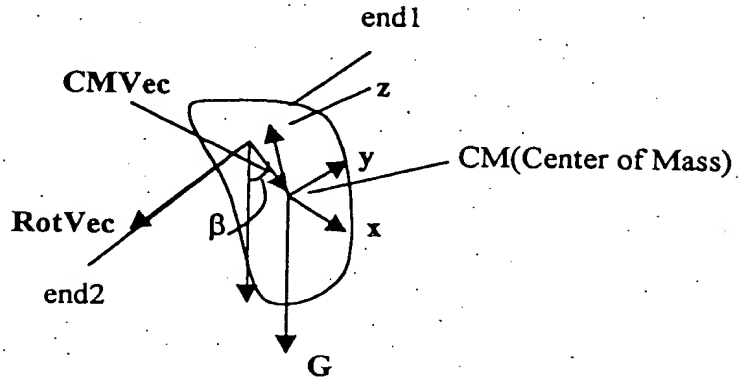

Fig. 34

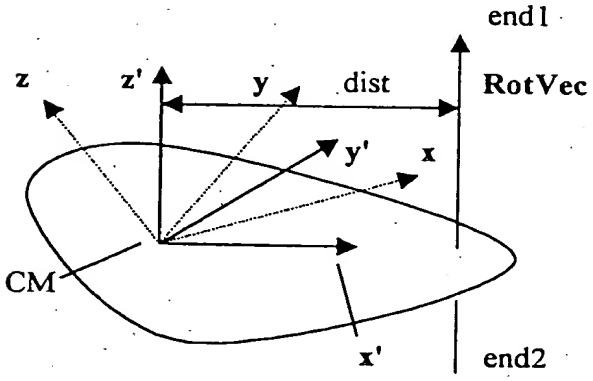

Fig. 35

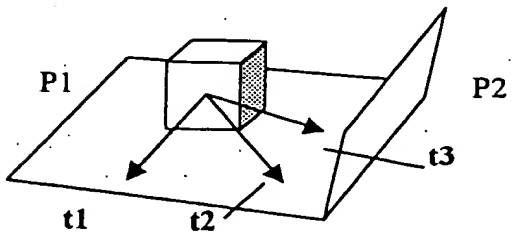

Fig. 36

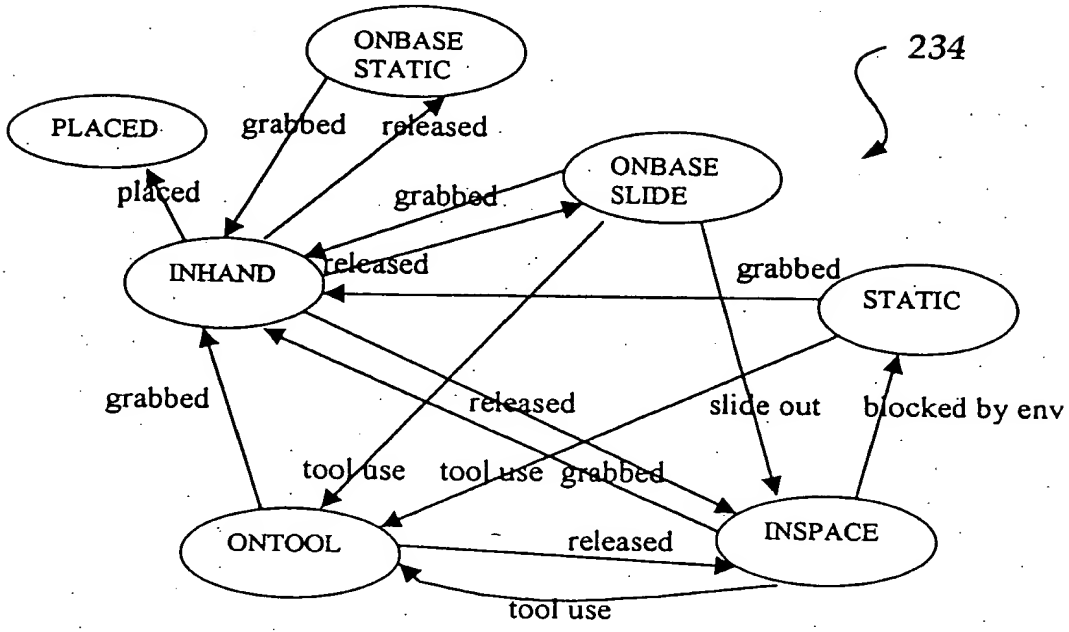

Fig. 37

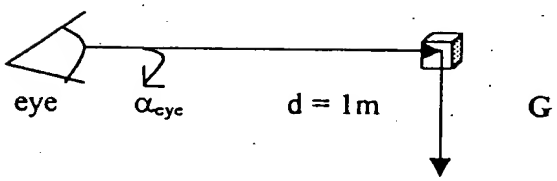

Fig. 38

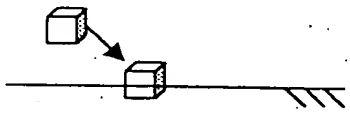

Fig. 39

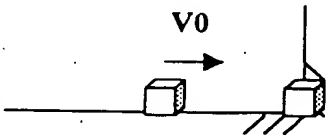

Fig. 40

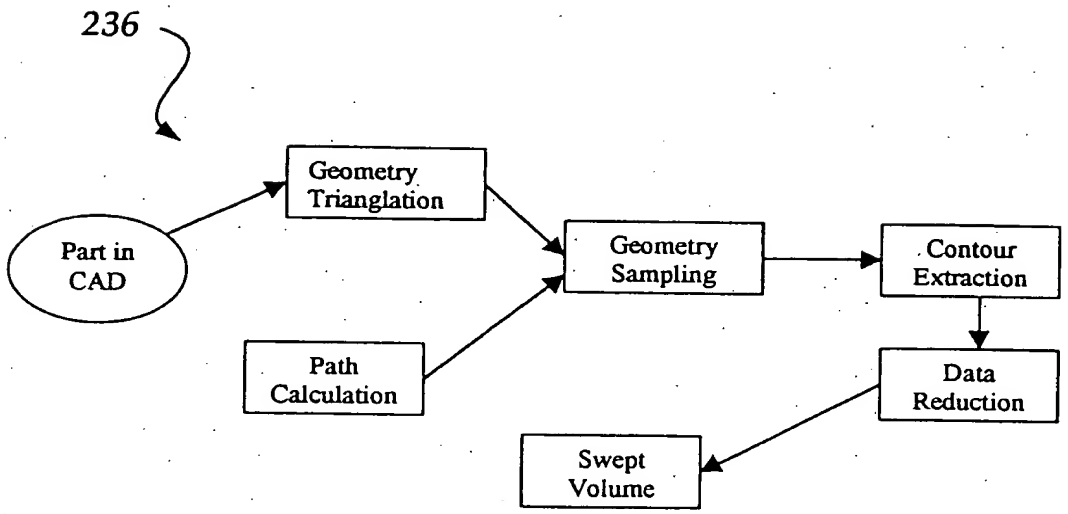
236
Geometry Trianglation
Part in CAD
Geometry Sampling
Contour Extraction
Path Calculation
Data Reduction
Swept Volume

Fig. 41

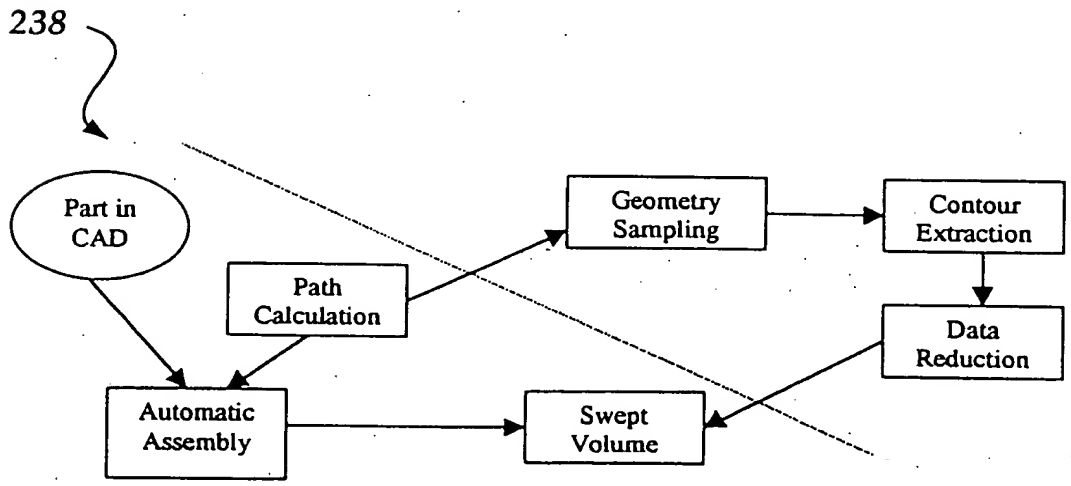
238
Part in CAD
Geometry Sampling
Contour Extraction
Path Calculation
Data Reduction
Automatic Assembly
Swept Volume

Fig. 42

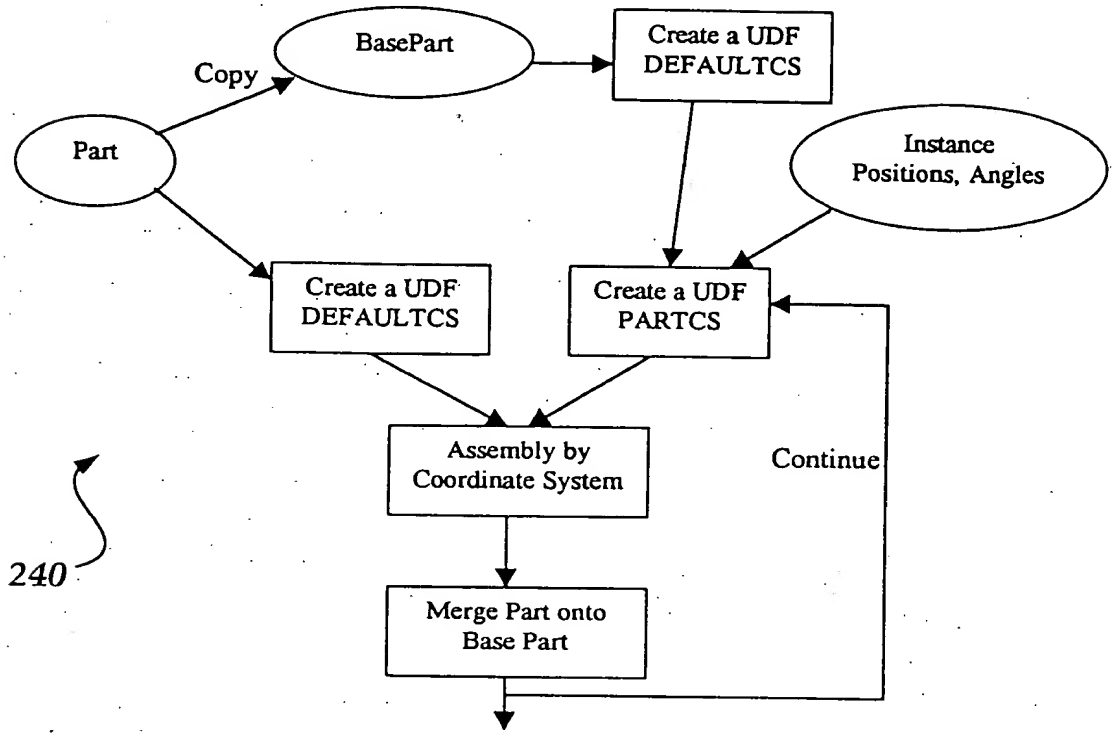
BasePart
Create a UDF DEFAULTCS
Copy
Part
Instance Positions, Angles
Create a UDF DEFAULTCS
Create a UDF PARTCS
Assembly by Coordinate System
Continue
Merge Part onto Base Part
240

Fig. 43

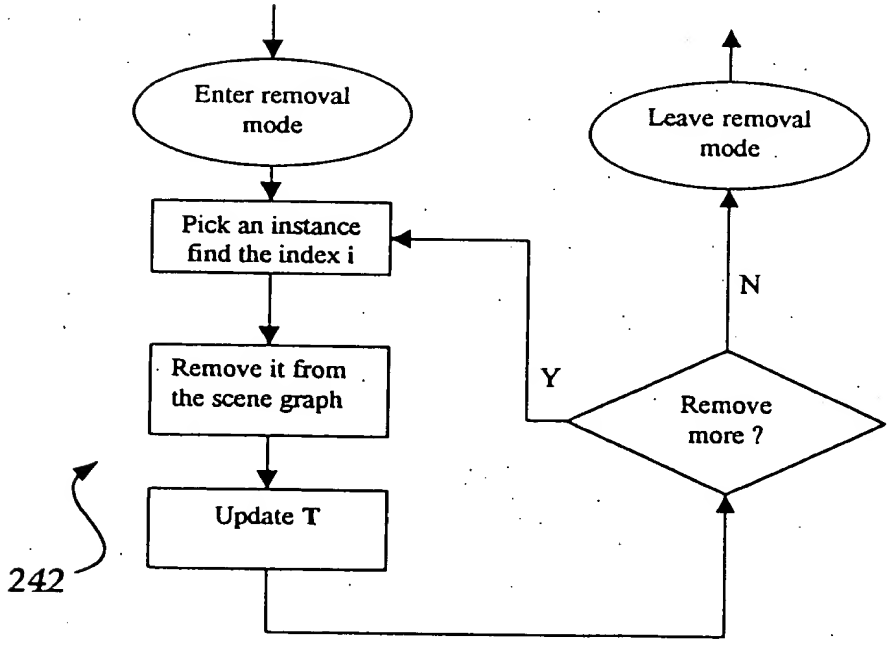
Enter removal mode
Leave removal mode
Pick an instance find the index i
N
Remove it from the scene graph
Y
Remove more ?
Update T
242

Fig. 44

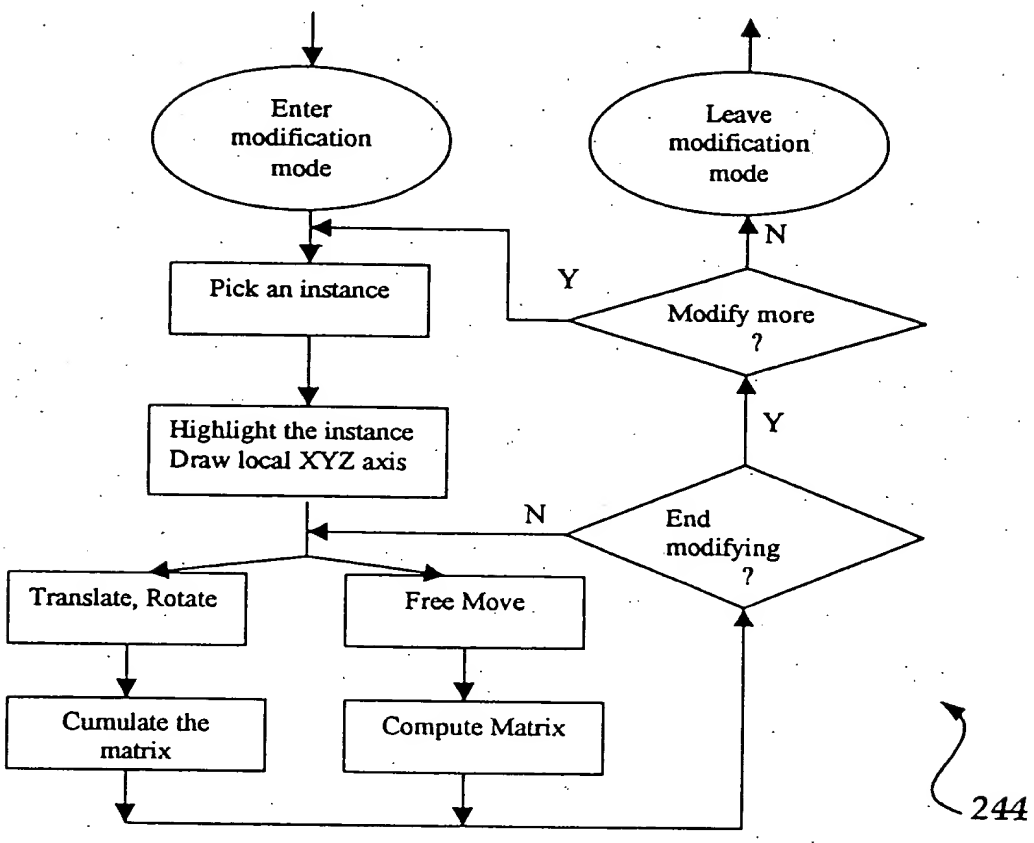
Enter modification mode
Leave modification mode
N
Pick an instance
Y
Modify more ?
Highlight the instance
Draw local XYZ axis
Y
N
End modifying ?
Translate, Rotate
Free Move
Cumulate the matrix
Compute Matrix
244

Fig. 45

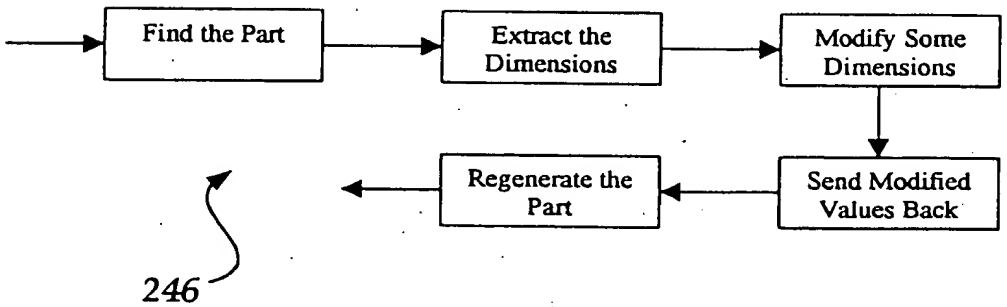
Find the Part
Extract the Dimensions
Modify Some Dimensions
Send Modified Values Back
Regenerate the Part
246

Fig. 46

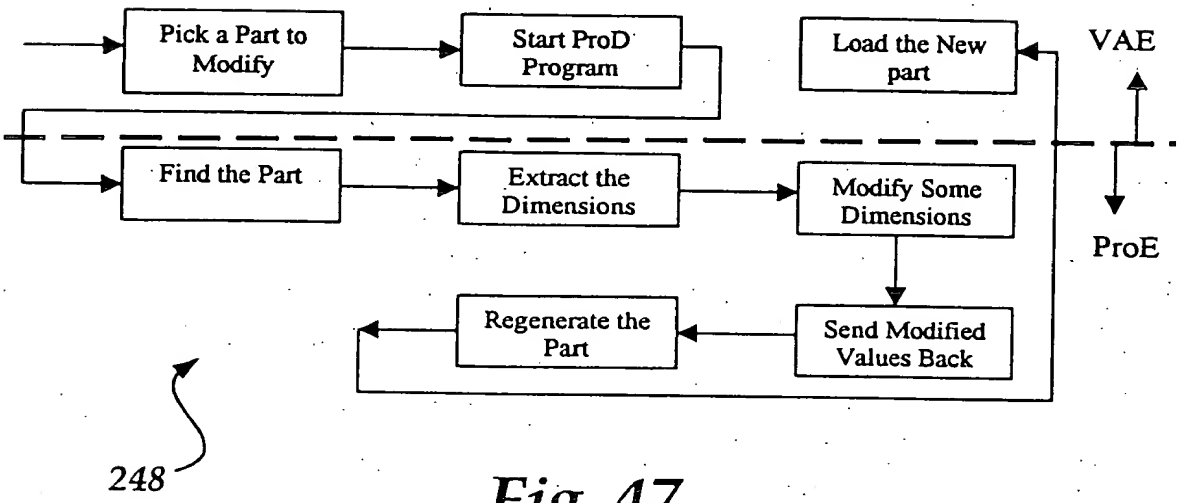
Pick a Part to Modify
Start ProD Program
Load the New part
VAE
Find the Part
Extract the Dimensions
Modify Some Dimensions
ProE
Regenerate the Part
Send Modified Values Back
248

Fig. 47

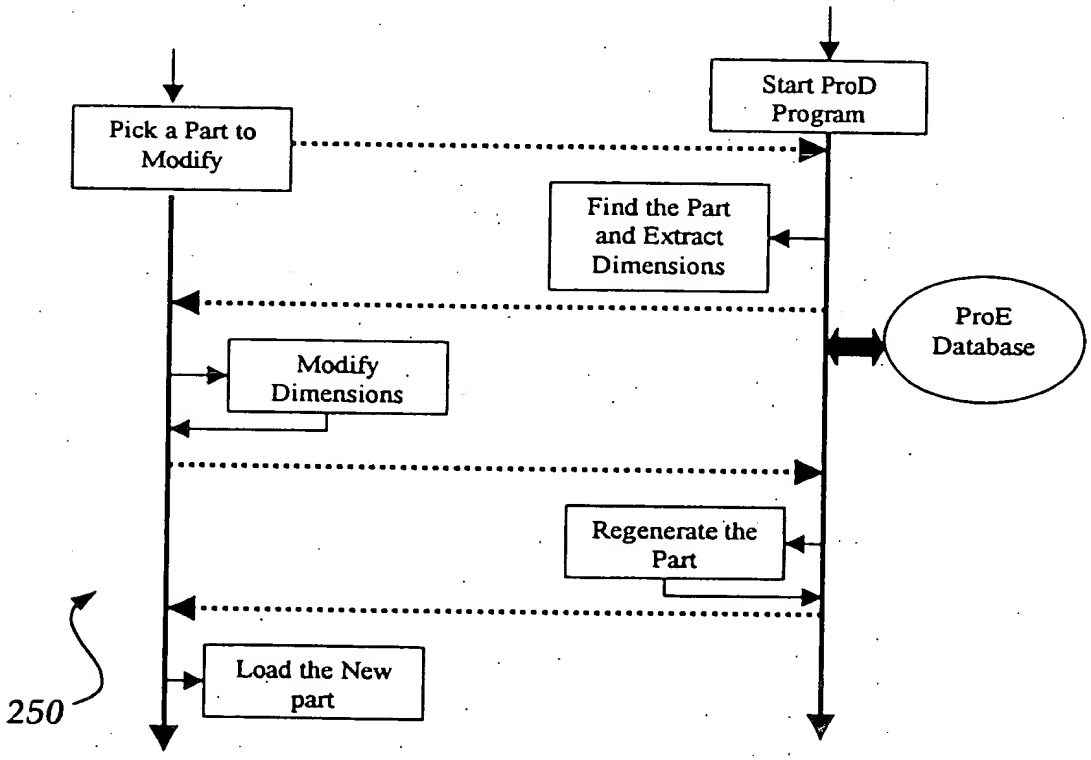
Start ProD Program
Pick a Part to Modify
Find the Part and Extract Dimensions
ProE Database
Modify Dimensions
Regenerate the Part
Load the New part
250

Fig. 48

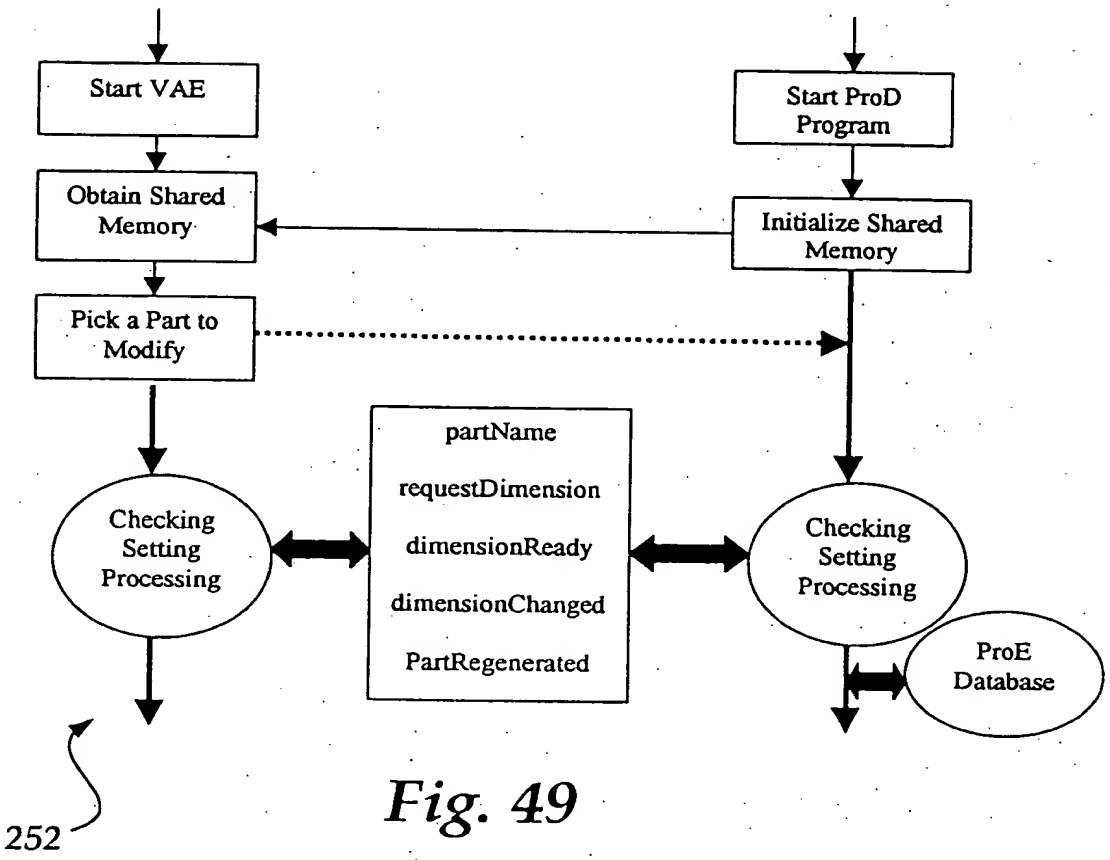

Fig. 49

```
If ( dimensionReady)
  {
        display dimensions;
        let user pick dimensions;
        modify the picked dimensions;
        dimensionChanged = ON;        /*set the flag    */
        dimensionReady = OFF;          /*reset the flag*/
  }
If ( partRegenerated)
  {
        load the new part;
        replace the old part;

        partRegerated  = OFF;         /*reset the flag*/
  }
```

Fig. 50

```
If ( requestDimensions)
  {
        find the part;
        load part into memory;
        extract the dimensions;
        dimensionReady = ON;          /*set the flag   */
        requestDimensions = OFF;      /*reset the flag*/
  }

If ( dimensionChanged)
  {
        get new dimensions;
        set the new dimensions;
        regenerate the part;
        partRegenerated = ON;         /*set the flag   */
        dimensionChanged  = OFF;      /*reset the flag*/
  }
```

Fig. 51

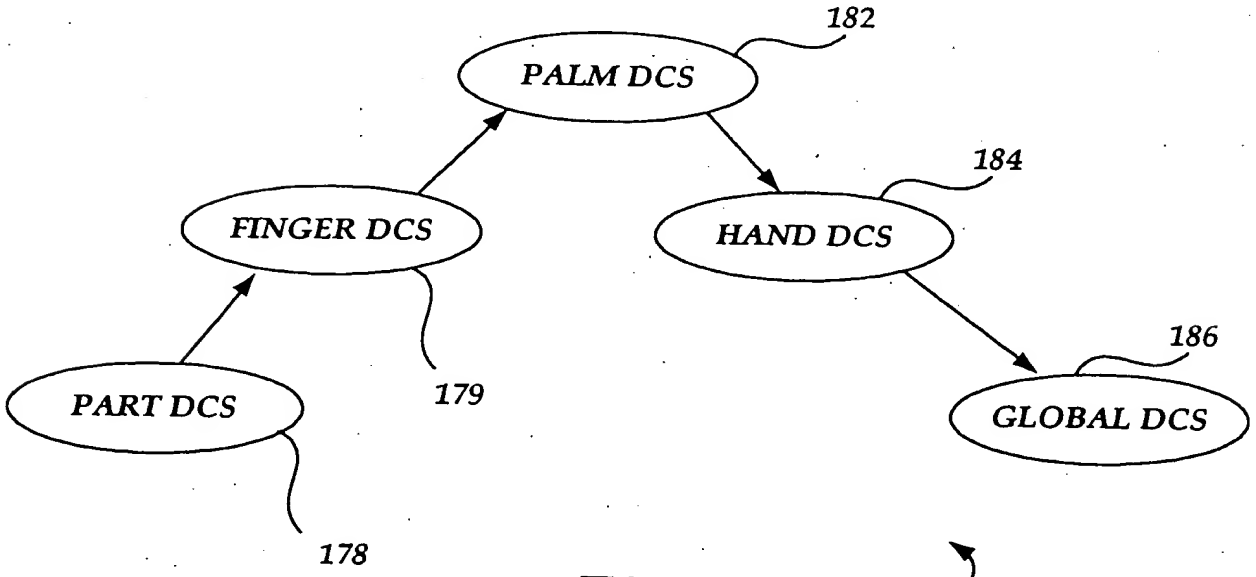

Fig. 53

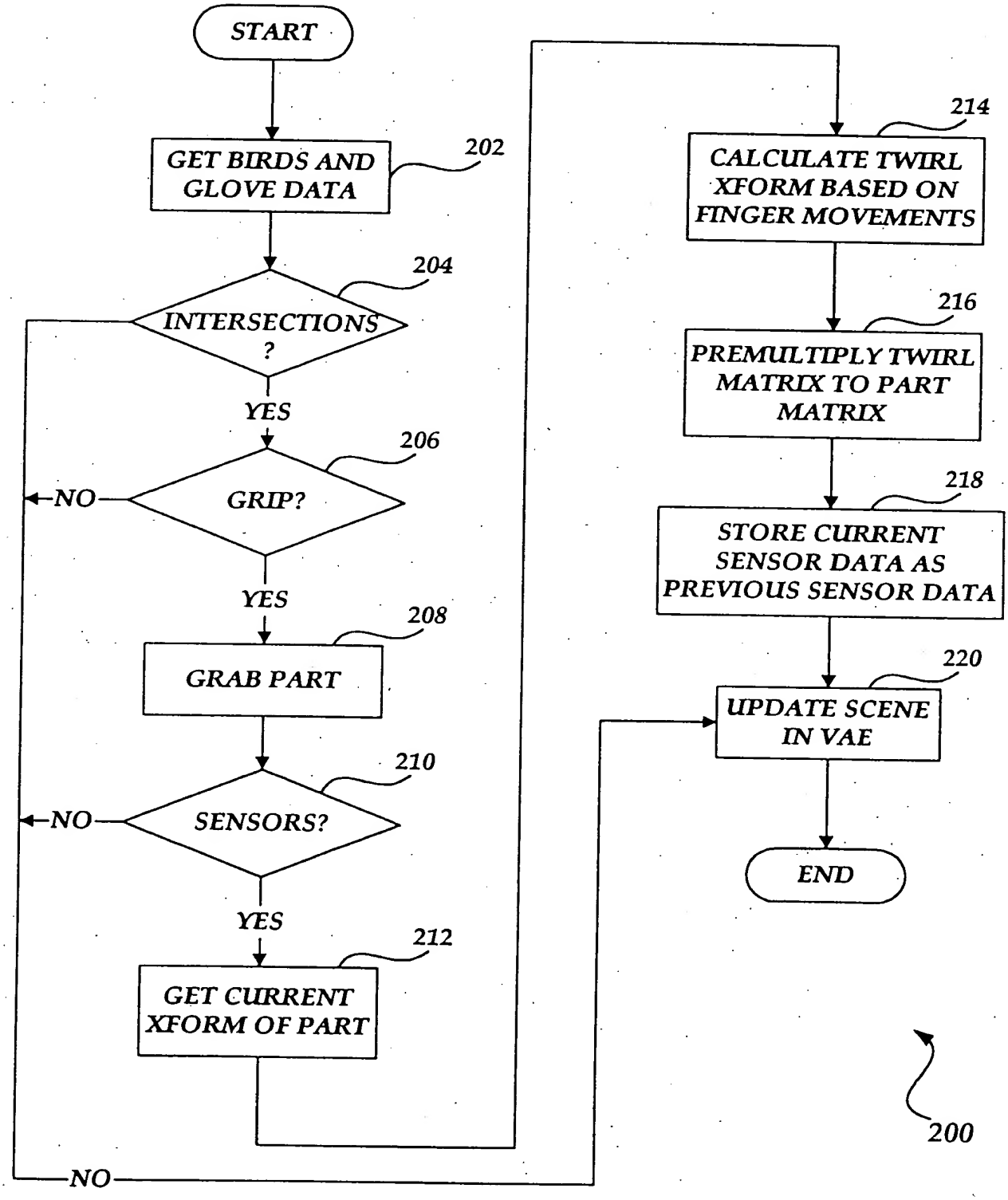
START
GET BIRDS AND GLOVE DATA
202
INTERSECTIONS ?
204
YES
NO
GRIP?
206
YES
GRAB PART
208
SENSORS?
210
NO
YES
GET CURRENT XFORM OF PART
212
NO
CALCULATE TWIRL XFORM BASED ON FINGER MOVEMENTS
214
PREMULTIPLY TWIRL MATRIX TO PART MATRIX
216
STORE CURRENT SENSOR DATA AS PREVIOUS SENSOR DATA
218
UPDATE SCENE IN VAE
220
END
200

Fig. 52

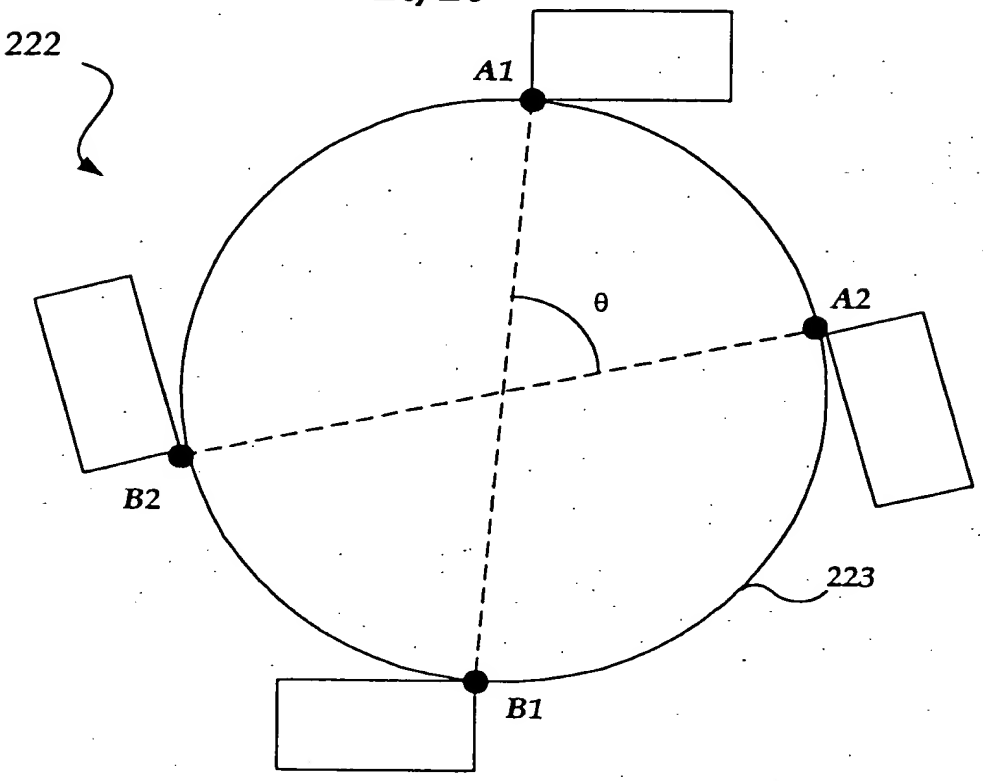
222
A1
θ
A2
B2
223
B1

Fig. 54

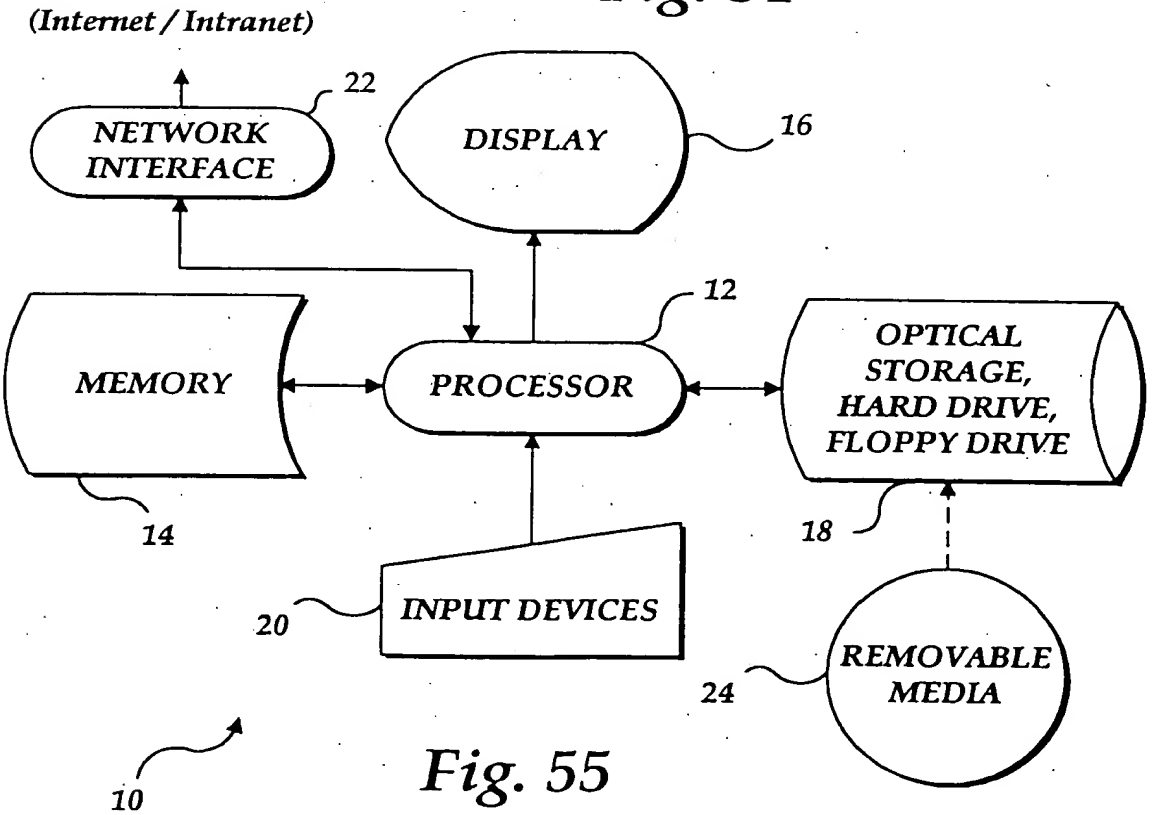
(Internet / Intranet)
NETWORK INTERFACE
22
DISPLAY
16
MEMORY
PROCESSOR
12
OPTICAL STORAGE, HARD DRIVE, FLOPPY DRIVE
14
18
INPUT DEVICES
20
REMOVABLE MEDIA
24
10

Fig. 55